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ABSTRACT

Studies comparing neuromotor and mental functioning of normal and disabled populations have shown that lower cognitive functioning is significantly related to lower motor functioning for retarded or disabled children but not for normal children. In an effort to further examine the relationship between these two functions, a study was conducted of 18 five-year-old boys, 18 five-year-old girls, 21 seven-year-old boys, and 15 seven-year-old girls. Four tests were administered to the participants: the McCarron Assessment of Neuromuscular Development (MAND) to evaluate neuromotor functioning; the Stanford-Binet Intelligence Scale: Fourth Edition (SB:FE) to obtain intelligence quotient (IQ) scores; and the Nebraska-Wisconsin Cognitive Assessment Battery (NEWCAB) to measure preoperations to formal operations in relations tasks, classification tasks, and number/length tasks. Correlational and simple regression analyses were run on the test scores to determine the predictability of cognitive outcomes from neuromotor results. Study findings included the following: (1) significant correlations were found between the neurodevelopment index of the MAND and the SB:FE composite IQ, and between the four SB:FE area scores and the NEWCAB total score; (2) specific sections of the MAND which predicted the IQ score were the kinesthetic integration, persistent control, and bimanual dexterity; and (3) the neurodevelopment index accounted for a considerably greater amount of variance in quantitative reasoning for 5-year-olds (31%) than for 7-year-olds (15%), but for less variance in short-term memory for 5-year-olds (17%) than for 7-year-olds (22%). Detailed tables of findings are attached. (AC)

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Abstract

Seventy-two five- and seven-year-old children were given the McCarron Assessment of Neuromuscular Development (MAND), the Stanford-Binet Intelligence Scale: Fourth Edition (SB:FE), and the Piaget-based Nebraska-Wisconsin Cognitive Assessment Battery (NEWCAB). The MAND composite Neurodevelopment Index predicted SB:FE composite IQ scores, the four SB:FE area scores, and some NEWCAB scores. MAND factor scores showed differential patterns of predicting SB:FE scores and NEWCAB task domain scores. Five- and seven-year olds differed with respect to the extent of relationships between neuromotor and mental measures.

Can Neuromotor Functioning Predict Stanford-Binet IQ Scores and Piagetian Cognitive Task Performance?

Research on relationships between neuromotor and mental functioning has shown inconsistent results. Studies comparing normal with disabled populations have shown that lower cognitive functioning is significantly related to lower motor functioning in mentally retarded children (Ulrich, 1983) and in learning disabled children (Haubenstricker, 1983). In contrast, most of the research on relationships between cognitive and motor functioning for normal children has provided low or no significant correlations (Rarick, 1980). These latter studies have been criticized for their use of measures employing only simple motor tasks (Rarick, 1980) or measures confounded with non-motoric variables which were not sensitive to developmental changes (Wolff, Gunroe & Cohen, 1985).

The current study was conducted with a view of neuromotor functioning as reflecting a dynamic neurological system with complex organization whose relationship with mental functioning may not be constant across development or across tasks. The purpose of the present study was to examine the nature of these presumed interrelationships among five- and seven-year-old children.

Method

Subjects

Subjects were 72 normal children in four groups: 18 five-year-old boys, 18 five-year-old girls, 21 seven-year-old boys, and 15 seven-year-old girls. The subjects were predominantly white with socioeconomic levels ranging from low- to upper-middle-class.

Measures

The McCarron Assessment of Neuromuscular Development (MAND; McCarron, 1982) was used to evaluate neuromotor functioning. The MAND is a standardized test comprised of fine and gross motor measures. It yields a composite score, the Neuromotor Developmental Index (NDI) which is a summation of 10 subtest scores, and four factor scores: Persistent

Control, Muscle Power, Kinesthetic Integration, and Bimanual Dexterity. Both quantity or extent of performance and quality or integrity of the specified movements are considered in scoring. The composite and factor scores have means of 100 and standard deviation of 15.

Mental functioning was measured with the Stanford-Binet Intelligence Scale: Fourth Edition (SB:FE; Thorndike, Hagen, & Sattler, 1986) and the Nebraska-Wisconsin Cognitive Assessment Battery (NEWCAB; Kalyan-Masih, Marshall, Tomes, & Kastl, 1975).

The SB:FE yields a composite IQ score and four area scores: Verbal Reasoning, Abstract/Visual Reasoning, Quantitative Reasoning, and Short-Term Memory. Fifteen subtests are distributed among the four areas. Composite IQ and factor scores have means of 100 and standard deviations of 16.

The NEWCAB is a Piaget-based battery of 16 tasks which measure preoperations to formal operations in three domains: Relations Tasks, Classification Tasks, and Number/Length Tasks. These ordinal scales yield a total score ranging from 0-110; relations tasks scores of 0-33, classification tasks score of 0-36, and number/length task scores of 0-41.

Procedure

The children were tested individually in their schools with accommodation to their academic schedules. Testing time for each subject totaled 3-4 hours divided into three testing sessions within one month for any given subject. During session one the NEWCAB was administered; session two, the SB:FE; and session three, the MAND.

Results

Means and Standard Deviations for the five- and seven-year-old subjects and totals on the MAND are presented in Table 1, on the SB:FE in Table 2, and on the NEWCAB in Table 3. Analysis of variance was used to examine age and sex differences in the MAND composite (NDI) and its four factor scores; the SB:FE composite IQ and four area scores; and the NEWCAB total and three domain scores. These analyses showed that seven-year-olds scored significantly higher than five-year-olds on the SB:FE areas Short-Term Memory ($F = 5.58$, p

< .05), and Quantitative Reasoning ($F = 4.64$, $p < .05$). As expected scores increased significantly with age on the NEWCAB total ($F = 18.89$, $p < .0001$), classification tasks ($F = 25.56$, $p < .0001$), and number/length tasks ($F = 6.05$, $p < .01$), while relations tasks did not differentiate between five- and seven-year-olds. Boys scored significantly higher than girls on the MAND factor Muscle Power ($F = 6.14$, $p < .01$).

Correlational analysis results are presented in Table 4. Significant correlations may be noted between the MAND composite NDI as well as all MAND factors except Muscle Power with the SB:FE composite IQ. The MAND composite NDI also correlates significantly with the SB:FE four areas scores, the NEWCAB total score, classification, and number/length scores. Correlational patterns suggest that MAND factors Kinesthetic Integration and Bimanual Dexterity bear a strong relationship to SB:FE scores, while Persistent Muscle Control is related to NEWCAB scores. Muscle Power, on the other hand, failed to show significant relations to any of the mental scores.

Simple regression analysis results (Table 5) showed that the MAND composite NDI predicted the SB:FE composite IQ as well as Verbal Reasoning, Abstract/Visual Reasoning, Quantitative Reasoning, and Short-Term Memory scores. The NDI also predicted the NEWCAB total, Classification and Number/Length scores.

Stepwise Multiple regression analysis was used to investigate which MAND factors were predictive of the various mental measure (Table 6). Kinesthetic Integration, Persistent Control, and Bimanual Dexterity were included in prediction of SB:FE IQ and together accounted for 30% of the variance. Bimanual Dexterity alone predicted Verbal Reasoning and Abstract/Visual Reasoning; Kinesthetic Integration alone predicted Quantitative Reasoning; Persistent Control alone predicted Short-Term Memory, NEWCAB total and Classification; while Kinesthetic Integration alone predicted Number/Length scores.

Regression analysis was further used to examine the predictive patterns of MAND for five- verses seven-year-olds (Table 7). The MAND composite NDI predicted SB:FE IQ, and

areas of Quantitative Reasoning, Abstract/Visual Reasoning, and Short-Term Memory for both age groups. MAND NDI, however, did not predict Verbal Reasoning for either age group. NDI accounted for a considerably greater of amount of variance in Quantitative Reasoning of five-year-olds (31%) than for seven-year-olds (15%), but for less variance in Short-Term Memory of five-year-olds (17%) than of seven-year-olds (22%). MAND NDI predicted NEWCAB total and Number/Length scores for five-year-olds, but failed to predict any NEWCAB scores for seven-year-olds.

Stepwise Multiple regression analysis (Table 8) showed that of the four MAND factors, Kinesthetic Integration alone predicted SB:FE IQ for five-year-olds while both Bimanual Dexterity and Persistent Control entered the prediction equation for IQ of seven-year-olds. MAND factors failed to predict Verbal Reasoning for either age group; Abstract/Visual Reasoning was predicted by Bimanual Dexterity alone for both groups. NEWCAB total was predicted by Persistent Control alone for both age groups; Classification by Persistent Control for five-year-olds, but by Persistent Control and Bimanual Dexterity for seven-year-olds; Relations was predicted by Bimanual Dexterity alone and Number/Length by Kinesthetic Integration alone for five-year-olds, while neither was predicted by any MAND factor for seven-year-old children.

Conclusions

This research suggests that neuromotor functioning may significantly influence a child's performance on mental tests differentially according to age and cognitive task. Implications for assessment, curriculum development, and the impact of neuromotor functioning on school achievement need to be further explored.

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Table 1

Means and Standard Deviations of MAND: McCarron Assessment of Neuromuscular Development

	Age					
	5 (n = 36)		7 (n = 36)		Total (n = 72)	
MAND Score	M	SD	M	SD	M	SD
Composite:						
Neuromuscular Development Index (NDI)	103.25	20.37	105.03	15.74	104.14	18.09
Factor Scores						
Persistent Control	98.19	23.12	104.72	16.25	101.49	20.11
Muscle Power	98.06	12.02	98.75	15.04	98.40	13.53
Kinesthetic Integration	95.83	19.69	93.89	20.22	94.86	19.54
Bimanual Dexterity	115.41	24.91	109.72	21.81	112.57	23.42

Note. The higher the score, the better the performance. NDI and factor scores are based on M = 100, SD = 15.

Table 2

Means and Standard Deviations of SBFE: Stanford-Binet Intelligence Scale Fourth Edition Scores

	Age					
	5 (n = 36)		7 (n = 36)		Total (n = 72)	
SBFE Score	M	SD	M	SD	M	SD
Composite IQ	94.06	11.38	97.53	10.00	95.79	10.78
Factor Scores						
Verbal Reasoning	101.11	8.80	98.36	8.69	99.74	8.79
Quantitative Reasoning	90.39	15.00	98.08	14.24	94.24	15.03
Abstract/Visual Reasoning	93.94	12.82	92.44	11.95	93.19	12.33
Short-Term Memory	94.25	15.08	102.61	14.35	98.43	15.21

Note. IQ composite and factor scores are based on M = 100, SD = 16.

Table 3

Means and Standard Deviations for NEWCAB: Nebraska-Wisconsin Cogntiive Assessment Battery

	Age					
	5 (n = 36)		7 (n = 36)		Total (n = 72)	
NEWCAB Score	M	SD	M	SD	M	SD
Total Tasks[a]	18.64	15.48	32.22	12.42	24.93	15.75
Domain Tasks						
Realtions[b]	7.61	5.44	8.00	5..52	7.81	5.44
Classification[c]	4.89	8.56	16.19	9.70	10.54	10.72
Number-Length[d]	5.14	5.30	7.56	2.60	6.35	4.32

[a]NEWCAB Total score range is 0-110.

[b]Relations Tasks score range is 0-33.

[c]Classification Tasks score range is 0-36.

[d]Number-Length Tasks score range is 0-41.

Table 4

Correlations Between McCarron Assessment of Neuromuscular Development, Stanford-Binet Intelligence Scale: Fourth Edition, and Nebraska-Wisconsin Cognitive Assessment Battery Scores.

MAND Variable[a]	SBIQ[b]	SBVR[c]	SBAVR[d]	SBQR[e]	SBSTM[f]	NEWCAB[g]	NRT[h]	NCT[i]	NLT[j]
Composite NDI	.60***	.29*	.46***	.48***	.43***	.30**	.17	.23*	.32**
Factor Scores									
Persistent Muscle									
Control	.36**	.21	.19	.25*	.35**	.39***	.07	.43***	.24*
Muscle Power	.22	.07	.16	.23*	.14	-.05	.08	-.12	.01
Kinesthetic Integration	.42***	.13	.35**	.36**	.29**	.10	-.03	.06	.31**
Bimanual Dexterity	.41***	.25*	.48***	.25*	.21	.17	.23*	.08	.17

* $p < .05$; ** $p < .01$; *** $p < .001$.
[a] McCarron Neuromuscular Assessment of Neuromuscular Development
[b] Stanford-Binet IQ Score
[c] Stanford-Binet Verbal Reasoning
[d] Stanford-Binet Abstract/Visual Reasoning
[e] Stanford-Binet Quantitative Reasoning
[f] Stanford-Binet Short-Term Memory
[g] Nebraska-Wisconsin Cogntiive Assessment Battery Total
[h] NEWCAB Relations Tasks
[i] NEWCAB Classification Tasks
[j] NEWCAB Number-Length Tasks

Table 5

Regression Analyses with MAND Composite Score on SB:FE and NEWCAB Scores

Variable	R^2	F
	(n = 72)	
SB:FE Composite IQ	.36	39.86***
SB:FE Area Scores		
Verbal Reasoning	.08	6.22*
Abstract/Visual Reasoning	.21	18.96***
Quantitative Reasoning	.23	20.86***
Short-Term Memory	.18	15.79***
NEWCAB Total	.09	6.88**
NEWCAB Domain Tasks		
Relations	--	--
Classification	.05	3.80*
Number-Length	.10	8.03**

* $p < .05$; ** $p < .01$; *** $p < .001$.

Table 6

Stepwise Multiple RegressionAnalyses with MAND Factors on SB:FE and NEWCAB

Dependent Variable	Significant MAND Factors	R^2	F
	(n = 72)		
SB:FE Composite IQ	Kinethetic Integration	.18	14.91***
	Persistent Muscule Control	.06	5.29*
	Bimanual Dexterity	.06	5.26*
SB:FE Area Scores			
Verbal Reasoning	Bimanual Dexterity	.06	4.8*
Abstract/Visual Reasoning	Bimanual Dexterity	.23	20.98***
Quantitative Reasoning	Kinethetic Integration	.13	10.28***
Short-Term Memory	Persistent Muscle Control	.13	10.02***
NEWCAB Total	Persistent Muscle Control	.15	12.37***
NEWCAB Domains			
Relations	Bimanual Dexterity	.05	3.95*
Classification	Persistent Muscle Control	.19	16.08***
Number-Length	Kinesthetic Integration	.09	7.19**

* $p < .05$; ** $p < .01$; *** $p < .001$.

Table 7

Regression Analyses with MAND Composite Score on SB:FE and NEWCAB Scores By Age Group

Variable	R^2	F
5-Year-Olds (n = 36)		
SB:FE Composite IQ	.36	19.41***
SB:FE Area Scores		
Abstract/Visual Reasoniong	.22	9.69**
Quantitative Reasoning	.31	15.52***
Short-Term Memory	.17	6.83*
NEWCAB Total	.14	5.46*
NEWCAB Domain		
Number-Length	.14	5.51*
7-Year-Olds (n = 36)		
SB:FE Composite IQ	.37	19.76***
SB:FE Area Scores		
Abstract/Visual Reasoning	.22	9.34**
Quantitative Reasoning	.15	5.90*
Short-Term Memory	.22	9.67**

* $p < .05$; ** $p < .01$; *** $p < .001$.

Table 8

Stepwise Multiple Regression Analyses with MAND Factors on SB:FE and NEWCAB By Age Group

Dependent Variable	Significant MAND Factors	R^2	F
	5-Year-Olds (n = 36)		
SB:FE Composite IQ	Kinesthetic Integration	.21	9.24**
SB:FE Area Scores			
Abstract/Visual Reasoning	Bimanual Dexterity	.26	12.23**
Quantitative Reasoning	Kinesthetic Integration	.27	12.86**
Short-Term Memory	Persistent Control	.11	4.09*
NEWCAB Scores			
Total	Persistent Control	.12	4.69*
Relations	Bimanual Dexterity	.15	6.07**
Classification	Persistent Control	.18	7.82**
Number/Length	Kinesthetic Integration	.23	10.05**
	7-Year-Olds (n = 36)		
SB:FE Composite IQ	Bimanual Dexterity	.23	10.16**
	Persistent Control	.10	5.08*
SB:FE Area Scores			
Abstract/Visual Reasoning	Bimanual Dexterity	.19	7.8**
Quantitative Reasoning	Muscle Power	.11	4.33*
Short-Term Memory	Kinesthetic Integration	.14	5.63*

Table 8 (continued)

Dependent Variable	Significant MAND Factors	R^2	F
NEWCAB Scores			
Total	Persistent Control	.14	5.53*
Classification	Persistent Control	.17	7.08**
Relations	Bimanual Dexterity	.08	3.98*

* $p < .05$; ** $p < .01$.